

CATALOGED BY DDC
AS AD No. 406 880

406 880

(4)

(5) 621 000
(7-9) NA

(6) RFI EVALUATION OF COMMERCIALY AVAILABLE
ALTERNATOR TYPE BATTERY CHARGING SYSTEMS

by

(10) H. A. Lasitter,

TN-505

(12) 27p.

(11) 24 May 1963,

(13) NA

(14) NA

(15) NA

(16) NA

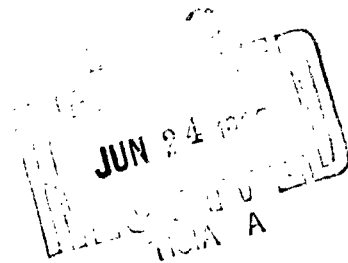
(17) NA

(18) NCEL

(19) Technical Note 505-

(20) u

(21) NA



U. S. NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA

NO OTS

19

RFI EVALUATION OF COMMERCIALLY AVAILABLE
ALTERNATOR TYPE BATTERY CHARGING SYSTEMS

Y-F006-09-207

Type C

by

H. A. Lasitter

ABSTRACT

Two battery charging systems ^{WERE} ~~have been~~ evaluated to determine the interference levels produced in the RF spectrum from 14 kc to 1,000 mc.

The major difference in the two systems is the method of regulation. One makes use of an electromechanical regulator whereas the other is completely transistorized.

The radiated interference from both systems exceed the broadband radiated limits specified by MIL-I-16910A.

^{WAS} ~~has been~~ The effect of noise suppression techniques on the conducted noise determined.

Techniques used to measure the radiated and conducted noise levels are discussed. The operation of each of the charging systems is also presented.

INTRODUCTION

The automotive battery charging system has long been known to be a source of radio interference. The long used d-c generator with arcing brushes and commutator segments is being replaced in some newer vehicles by an alternator with self-contained semi-conductor rectifiers.

This study was made to determine the electromagnetic noise generated in the frequency range 14 kc to 1,000 mc by the new alternator type battery charging systems for vehicles. Two commercially available systems have been evaluated, both for radiated and conducted interference.

One system incorporates a solid state regulator while the second system makes use of a conventional electromechanical regulator. These two types are representative of alternator type charging systems that were commercially available at the time the evaluation was started.

Charging of the battery is accomplished by utilizing the rectified output of a motor driven alternator. The alternator used in both systems is similar, the principal difference is in the method of regulation.

GENERAL DISCUSSION

For convenience in evaluating the systems, a test fixture was fabricated so that the alternators would be driven by a constant speed 3-phase 220 vac induction motor. Provisions were made to vary the shaft speed of the alternator from 2,000 rpm to over 9,000 rpm. Speed changes were made using selected pulley sizes on the motor along with the proper belt lengths.

In addition, the test fixture held a 12-volt rechargeable battery and a 15-ampere load to discharge the battery. Indications of battery charge or discharge were monitored with a 40-0-40 ampere meter. The fixture was made portable and for the interference tests it was moved into a 10 x 10 x 8 foot screen room.

The use of a fixture for the evaluation permitted only the noise generated by the battery charging system to be measured. If measurements were made with the systems installed in a vehicle, the noise generated by the ignition system could possibly override the noise from the charger.

For all the interference tests the motor shaft speed was maintained at 3,800 rpm. The changes in noise level for changes in shaft speed have been determined and are indicated in the report. The charging level during all of the tests was 20 amperes or more.

RADIATED MEASUREMENTS

Radiated noise measurements were made using standard RIFI noise meters over the frequency range from 14 kc to 1,000 mc. The specific noise meters used in this test are shown in Table I.

TABLE I. Instruments used in measuring radiated interference.

Meter Type	Serial Number	Frequency Range
NM-10A	159-7	14 - 250 kc
NM-20A	156-19	0.15- 25 mc
NM-30A	208-30	20 - 400 mc
NM-52A	292-41	375 -1000 mc

These radiated measurements have been expressed in terms of microvolts/meter/kilocycle. In this way a comparison can be made to broadband radiated interference limits as given by MIL-I-16910A.

CONDUCTED MEASUREMENTS

The equipment used to make conducted noise measurements is shown in Table II. These measurements were made primarily to determine the effect of noise suppression techniques and are not compared to an existing standard.

Table II. Instruments used in conducted noise test.

Item	Model	Manufacturer	Frequency Range
Panoramic Spectrum Analyzer	SPA-3/25CE	Singer-Metrics	1- 23 mc
Tuning Head for Analyzer	-	Singer-Metrics	25- 200 mc
Tuning Head for Analyzer	-	Singer-Metrics	200- 400 mc
Tuning Head for Analyzer	-	Singer-Metrics	400-1000 mc
Impulse Generator	IG-115	Empire Devices	UHF
VHF Step Attenuator	355 A	Hewlett Packard	0- 12 db
VHF Step Attenuator	355 D	Hewlett Packard	0- 120 db

The arrangement used to monitor these noise levels is shown in Figure 1. The coaxial switch is first set so that a signal from the alternator is fed into the analyzer (via the appropriate tuning head, depending upon the frequency of interest) and the gain of the analyzer adjusted to some arbitrary level. In all cases this level was such that overloading of the analyzer did not occur. The switch was then changed to the impulse generator position and the attenuator adjusted until the same level was obtained on the analyzer. The output of the impulse generator was set at maximum (100 db/ μ v/megacycle, peak). In this manner the noise out of the alternator was compared to a known amplitude signal from the impulse generator. A photograph of a typical noise spectrum displayed on the analyzer is shown in Figure 2. The instrument was set for a center frequency of 14 mc with a 5 mc sweep width.

DATA OBTAINED FROM ELECTROMECHANICAL REGULATOR SYSTEM

This charging system has the capability to charge a 12-volt wet cell at a 40-ampere rate. The charging current is regulated by varying the field current of the alternator in accordance with the battery voltage, i.e., if the battery voltage is low, more current is allowed to flow through the field winding, yielding a higher charging current. When the battery voltage increases, the regulator reduces the field current and thereby decreases the charging current. A schematic diagram of the alternator regulator system is shown in Figure 3. Operation of the unit is as follows:

1. The ignition switch S_1 is closed, permitting current to flow through the field winding by means of the normally closed contact of K_1 . The dash lamp will be on.
2. After starting, the rotating field will supply a voltage to the stator winding, closing relay K_2 . This will cause the dash lamp to go out. At the same time a voltage will be available to the winding of relay K_1 . The output of the diode rectifier assembly is furnishing charging current to the battery.
3. A second winding on relay K_1 is carrying the field current and will set up an opposing magnetic field on the contact arm of this relay. If this current is high, the contact arm will cause the field winding to be grounded and turn off the charging current to the battery. This field current will be shut off only if the magnetic field in the second winding is greater than that established by the 5.5 ohm winding.
4. The action described occurs very rapidly and will result in an almost continuous interplay between the field charging current and the output battery voltage. Thus, the rate at which the battery is charged will vary depending upon the voltage at the battery terminal of the regulator.

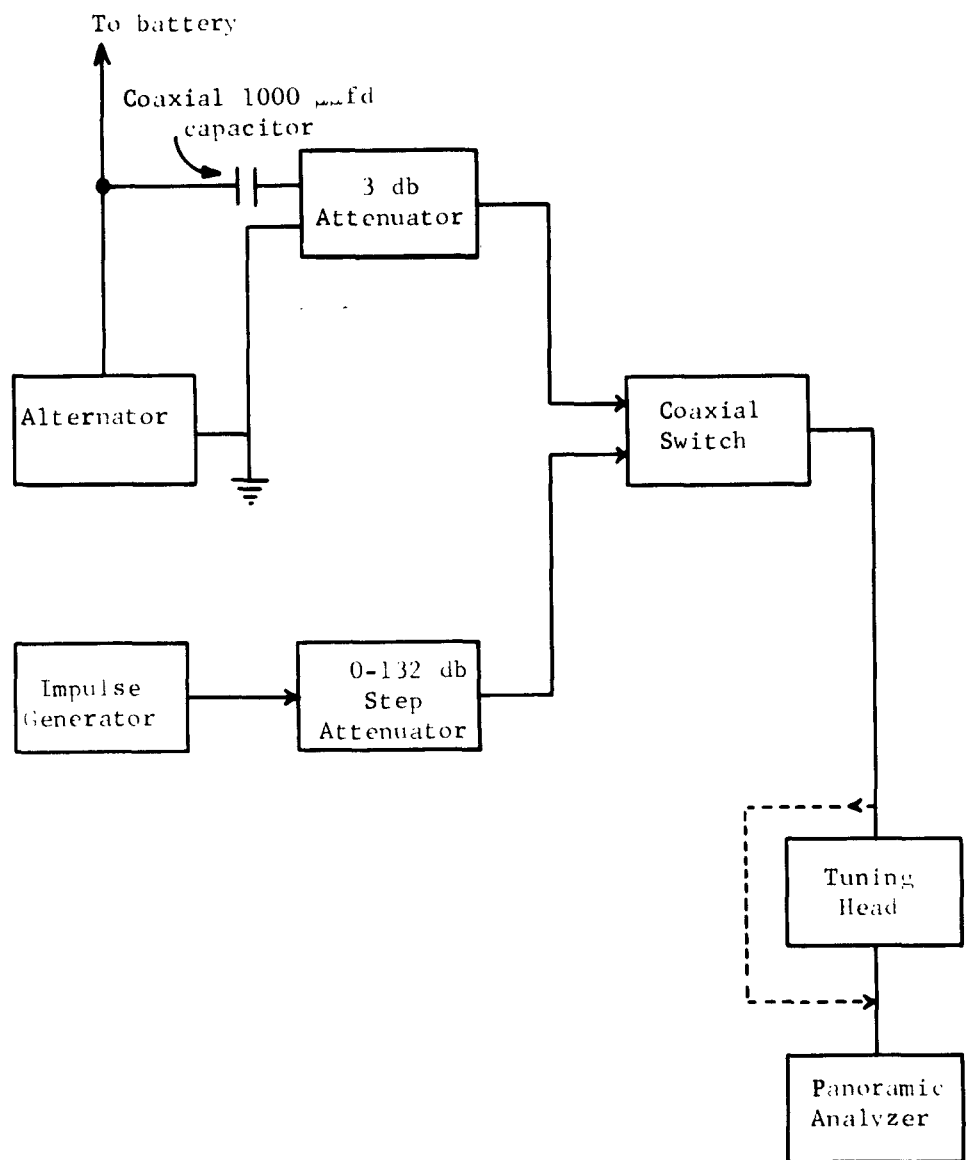


Figure 1. Equipment arrangement used to make conducted noise measurements.

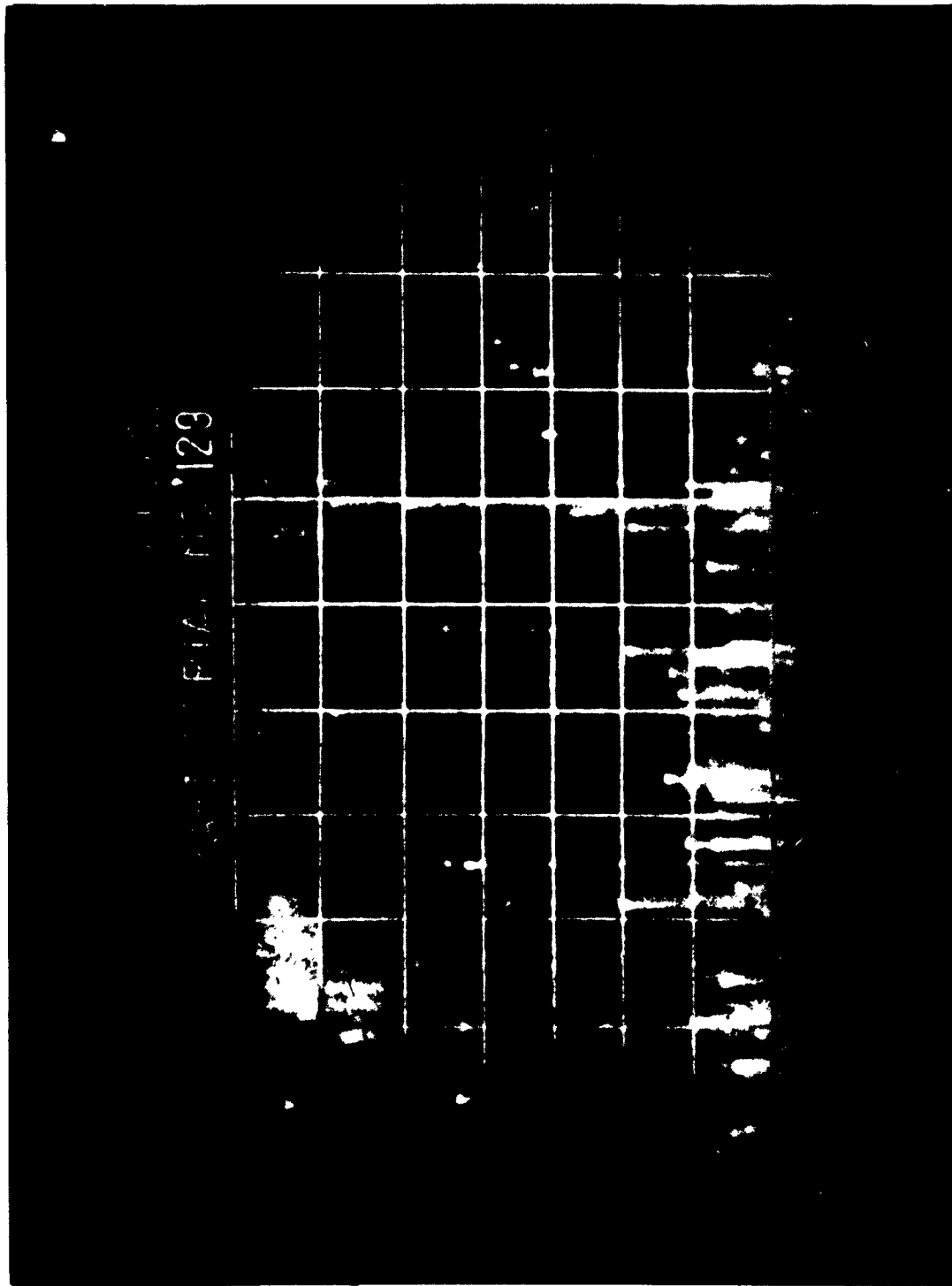


Figure 2. Photograph of noise spectrum produced by battery charging system.

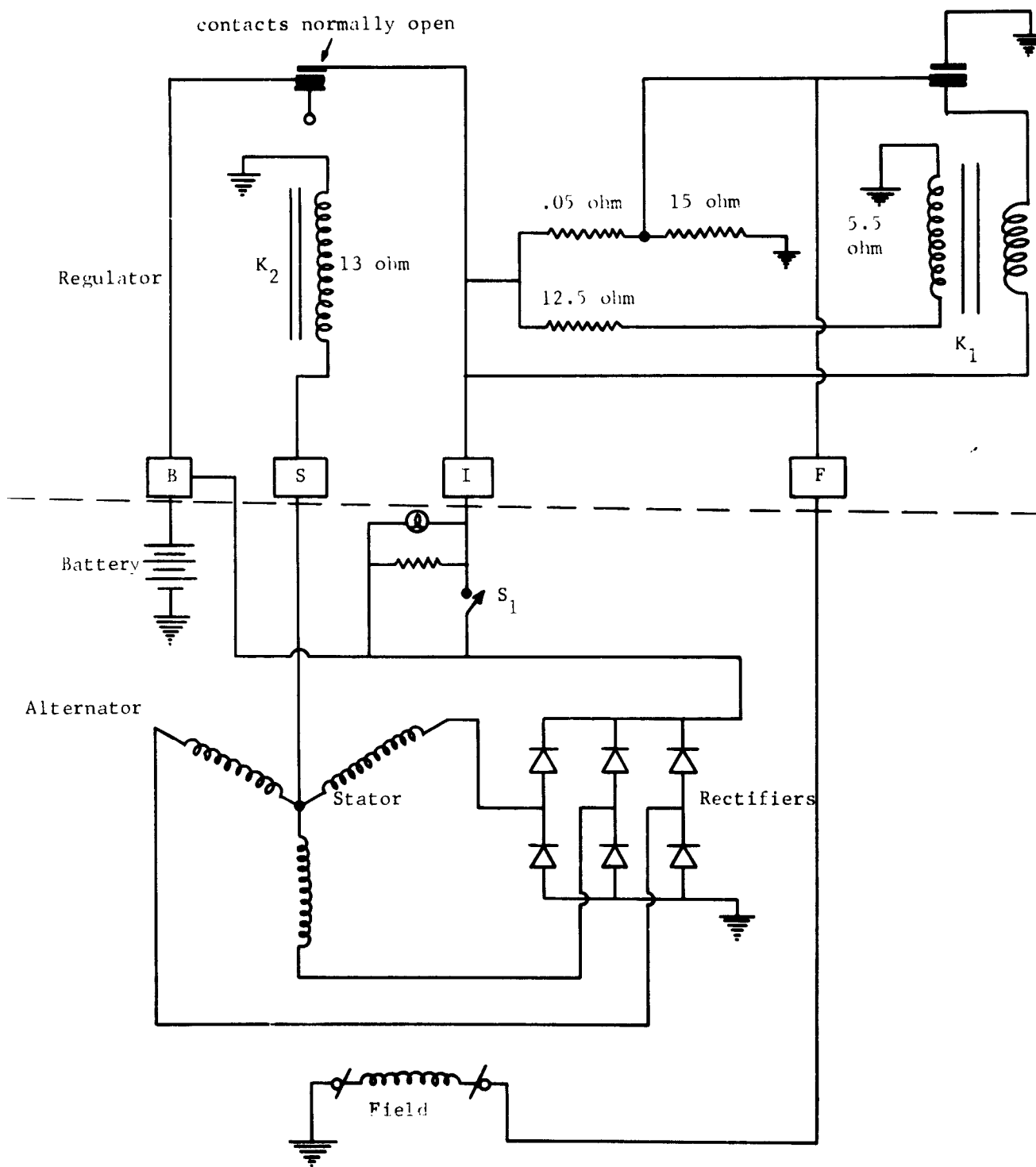


Figure 3. Circuit diagram of electromechanical charging system.

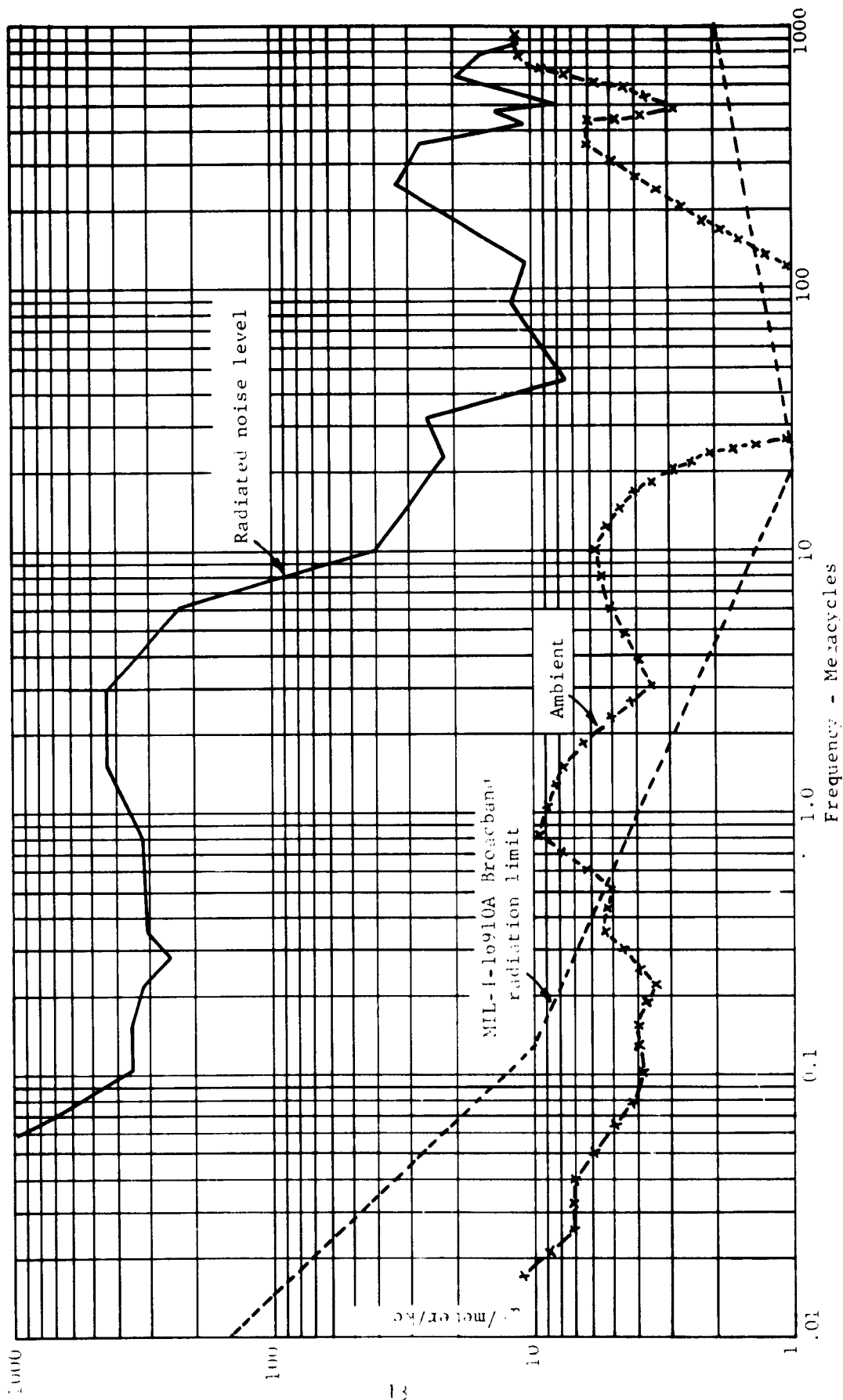
As a result, there is an almost continuous arcing of the relay contacts of K_1 . The regulator will tend to generate noise in the radio frequency spectrum because of the rapid switching of the controlling relay K_1 . This noise will be radiated by the wiring associated with the regulator. Measurement of this noise has indicated that the levels generated exceed the broadband radiation limits specified by MIL-I-16910A. Figure 4 shows these measured values, along with an ambient noise level in comparison with the limits set down by MIL-I-16910A. Ambient levels were determined with the charging system turned off. Preliminary measurements of the 220 volt 3-phase motor used to drive the alternator showed that the noise generated by the motor was at the ambient level throughout the spectrum under consideration.

The conducted noise levels are shown in Figure 5. The noise on the charging lead is given for the situation where no bypass is used and also where a 0.2 μ fd disc ceramic capacitor is used between the charging lead and the case of the alternator. It can be noted that the bypass is effective until the resonant frequency of the capacitor is reached, at which point the noise measured is essentially that without the bypass. The tuned circuit formed by the capacity of the condenser and the inductance of its leads causes a rise in the measured noise in the region between 10 and 20 mc, approximately. The minimum measurable level of the equipment, see Figure 1, was determined by feeding the impulse generator into the analyzer (via the coax switch, attenuator and tuning head), increasing the attenuator setting and noting the level at which the impulse generator could no longer be detected.

DATA OBTAINED FROM SOLID STATE REGULATOR SYSTEM

The circuit diagram of this system is shown in Figure 6. Operation of this circuit is as follows:

1. Closing the ignition switch applies voltage to the divider network in the regulator associated with transistor SA 225. This network establishes a stabilized bias for the transistor base. Variation in the battery voltage will cause a proportional change in the base voltage of transistor SP 441, through transistor SA 225.
2. Since the base of SA 225 is fixed by the Zener diode Z13, the voltage applied to the base of SP 441 will tend to cause SP 441 to vary its emitter to collector resistance. This in turn will permit more or less field current to flow, thus regulating the amount of charging current available to the battery.
3. As an example, suppose the battery voltage is low. The base of SA 225 is held constant at the Zener voltage, $V_Z = 13$ volts. Because of a reduced battery voltage SA 225 will begin to conduct, increasing the voltage across the 100 ohm resistor in the base circuit of SP 441. This



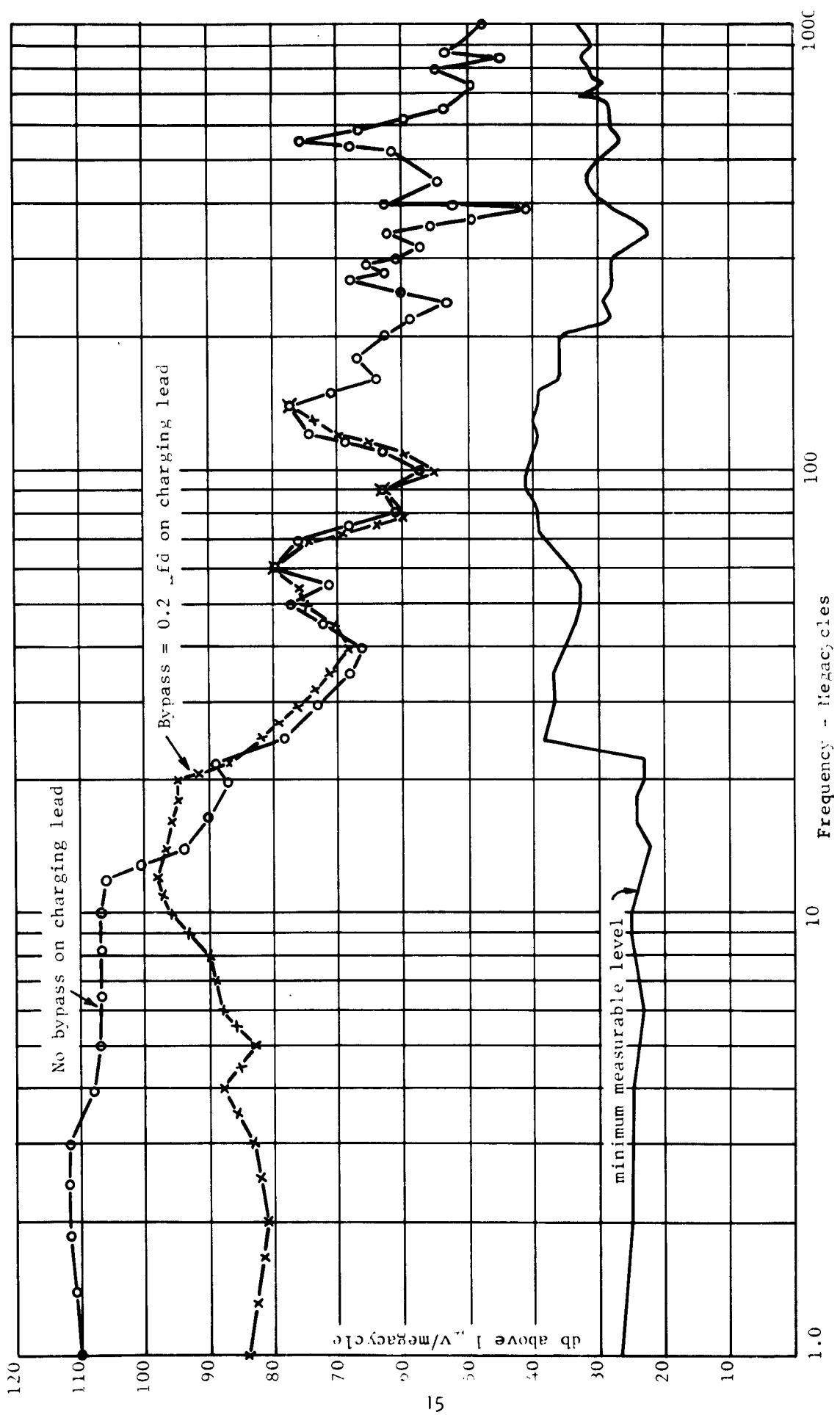


Figure 3. Conducted noise measurement for electromechanical charging system.

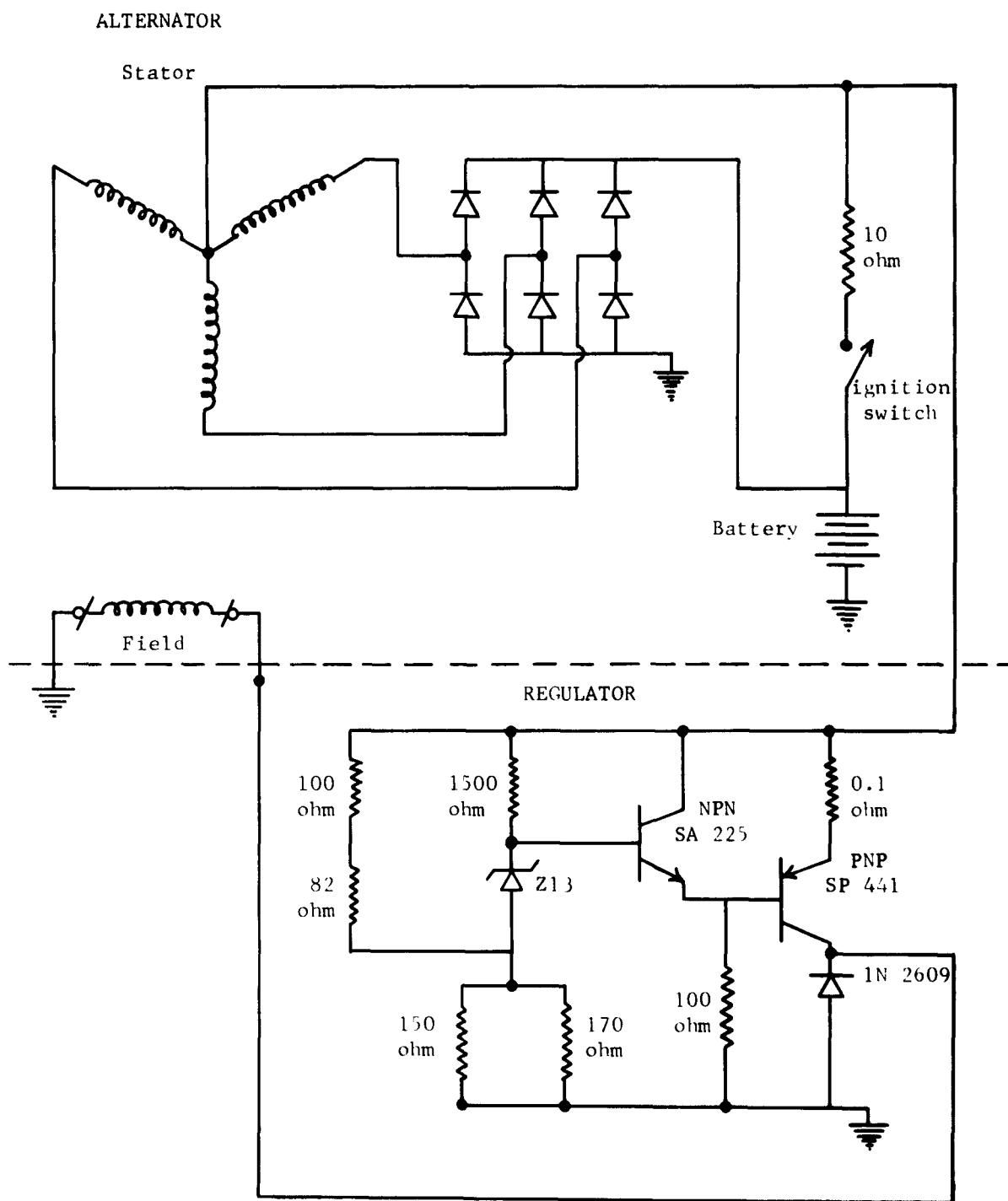


Figure 6. Circu diagram of solid state battery charging system.

increase in base voltage will cause SP 441 to conduct and permit more current to flow through the field winding. This in turn will force the battery voltage up and ultimately reduce the amount of current passed by SP 441. The charging current will be reduced by the reduction in field current. The battery is thus charged each time the voltage output drops.

The principles used in this regulator are identical to the electro-mechanical regulator, except relay contacts are eliminated in this system. As a result, this system should be inherently quieter than the relay controlled type. The radiated noise from this system is shown in Figure 7. Indications are that this system still presents a large amount of noise in the RF spectrum and clearly exceeds the noise limits of MIL-I-16910A. The noise level is not as high as that found in the relay controlled system, but is still objectionable.

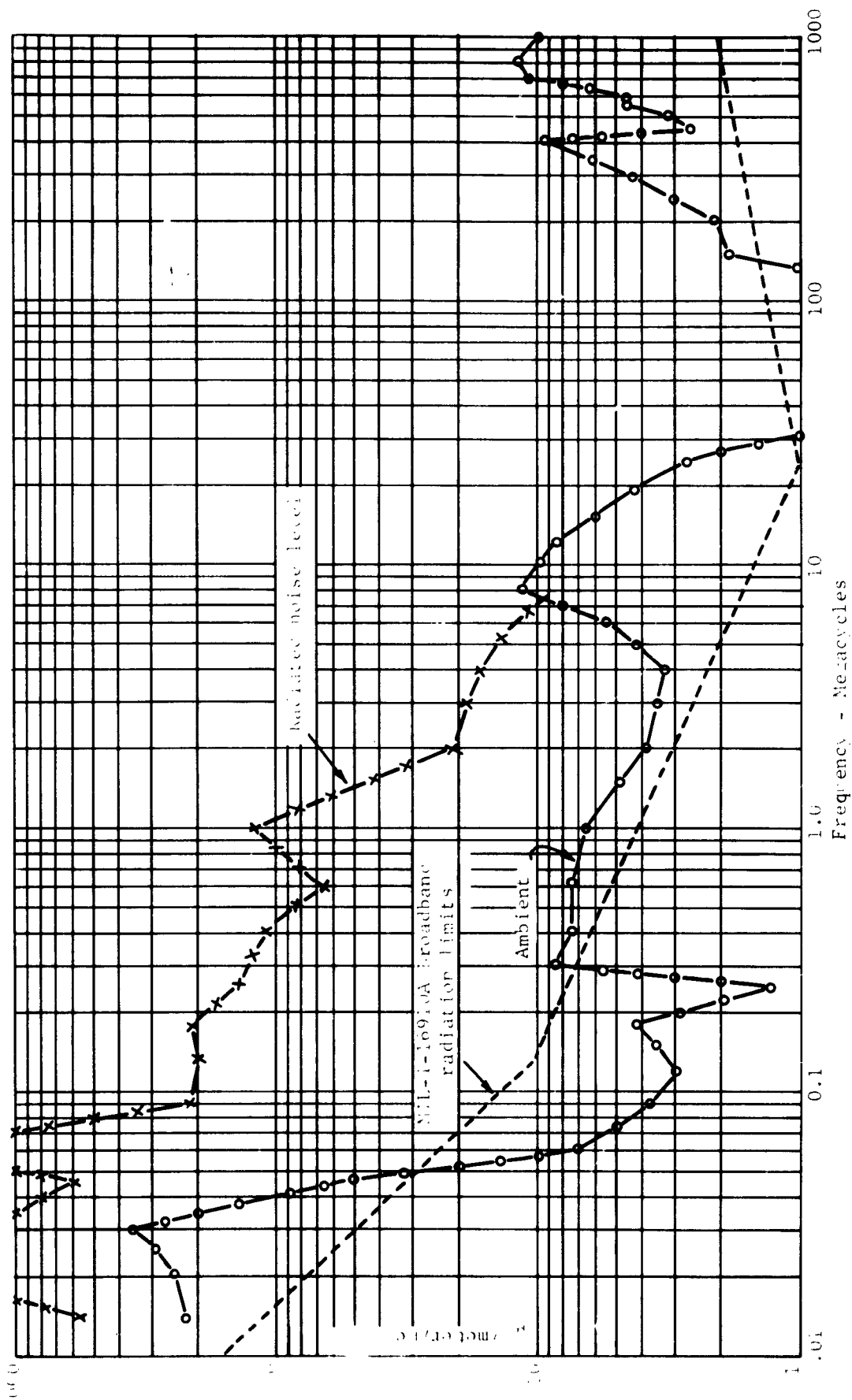
Both of the alternators make use of slip rings and brushes to carry the field currents which still constitutes a source of RF interference.

The variation in the radiated noise level at 100 kc with changes in alternator shaft speed have been determined and are shown in Table III. Shaft speeds were measured using a Strobotac type 631-B manufactured by the General Radio Company.

Table III. Indicated noise voltage for various shaft speeds.

Alternator Shaft rpm	100 kc - db v		
	FI	QP	Peak
2180	27	35	38
2450	27	34	37
4000	34	42	46
6700	42	47	50
9350	46	55	71

Conducted measurements indicate that the noise level encountered with this system are also below that obtained with the electromechanical system. Curves for no bypass capacitor, a 0.2 μ fd disc ceramic bypass and a tubular 0.1 μ fd paper capacitor are given in Figure 8. In addition the instrument noise is presented to show measurable limits.



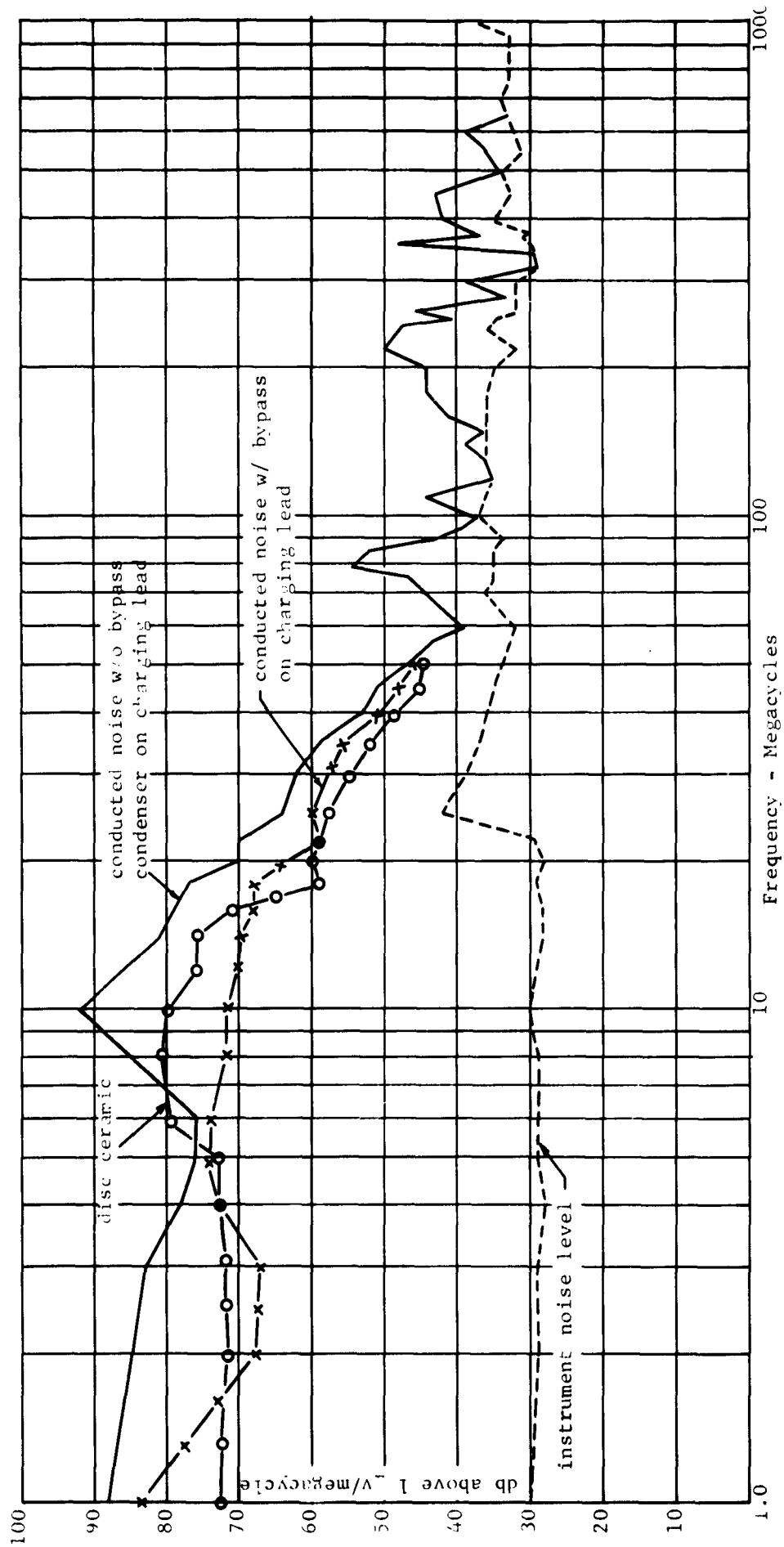


Figure 8. Conductive noise for solid state battery charging system.

CONCLUSIONS

Data obtained on two different types of alternator battery charging systems indicates that radiated interference exceeds MIL-I-16910A specifications. The incorporation of these systems in a vehicle (with the hood closed) will give an approximate 20 db (10:1) reduction in the radiated interference. Even with the hood closed, noise in the low frequency spectrum will still be above the allowable limit. See Figures 4 and 7.

Conducted noise is not particularly amenable to suppression with conventional bypassing techniques. The use of extremely low inductance components will be necessary to reduce this noise level.

RECOMMENDATION

The most direct approach to reduction of RF interference is to eliminate the source of the noise. In both systems use is made of slip rings and brushes to carry the field current. A development program should be undertaken to produce a truly brushless battery charging system.

FOR OFFICIAL USE ONLY

The battery charging systems that have been evaluated in this note are listed below with specific reference to manufacturer's designations.

1. The battery charging system using the electromechanical regulator was obtained from Ford Motor Company. The alternator is Type H & A, rated at 40 amperes charging current and 15 volts output. The regulator part number is C3Kf-10316-C.

2. The system using the solid state regulator is manufactured by Motorola, Inc. The alternator has the designation Model A-45 and the transistorized regulator is marked TVR 12NX1.